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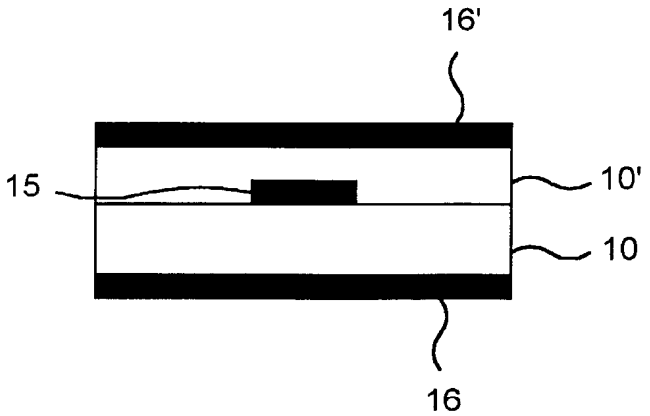
(54) Title: MICROWAVE DEVICE USING PHOTONIC BAND GAP STRUCTURE



(57) Abstract: A PBG (Photonic Band Gap) microwave devices employing a field shield structure. The microwave devices include microwave filter, multiplexer, antenna and waveguide. The devices of the present invention are characterized in that a dielectric layer is coated on a micro-strip metal line having a PBG structure formed on a substrate, and a ground metal film for field shield is formed on the dielectric layer. The devices can be kept in a rolled structure since they are made of flexible materials. In an embodiment of the present invention, the micro-strip metal line includes "photonic bandgap structures" having different periods, resulting in a microwave device having a narrow pass band within a wide stop band. According to the present invention, malfunction of the devices due to the interference between the signals of opposite micro-strip metal lines can be avoided regardless of the spacing of the lines, especially when miniaturizing the devices using stacking structures. Therefore, compact-sized devices can easily be realized.

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MICROWAVE DEVICE USING PHOTONIC BAND GAP STRUCTURE

TECHNICAL FIELD

The present invention relates to microwave devices, and more particularly, to microwave devices employing a PBG (photonic bandgap) structure, e.g. a filter, a multiplexer, an antenna, and a waveguide for microwave. Here the microwave means generally electromagnetic waves that belong to of the frequency band of about 100㎒ ~ 60㎓.

BACKGROUND ART

Traditional microwave filters that have an RLC device formed on the substrate or use SAW(Surface Acoustic Wave) are difficult to simplify or miniaturize since they are bulky or require difficult manufacturing methods. Also, their manufacturing methods require great skill and expensive equipment, which entails a very high cost of mass production. For example, U.S. Patent No. 5,748,057 granted to De Los Santos discloses a microwave divider employing PBG that comprises a plurality of dielectric rod lattices of different periods to divide signals according to frequency. However, it was still difficult to miniaturize a microwave filter even by means of the above art.

Therefore, the inventors of the present invention repeated researches and developed a microwave filter and a microwave multiplexer that are capable of simplification and miniaturization. They were disclosed in Korean Patent Application No. 2000-23754. But there is some fear that, in case a microwave filter or multiplex is miniaturized through stacking or integration, with adopting the structure of devices disclosed in the Korean Patent Application No. 2000-23754, signals may interfere with each other and cause malfunction in devices when a space between opposing micro-strip metal lines becomes very small.

To avoid this, it may be taken into consideration that a metal shield film is formed at a distance from a microwave device. But maintaining a gap by means of a certain space is not only technically difficult, but also has an adverse effect on the durability of a product.

DISCLOSURE OF THE INVENTION

Accordingly, an object of the present invention is to provide microwave devices employing a PBG structure that can reduce the occurrence of malfunction due to interference between the signals of adjacent microstrip metal lines even when the devices are manufactured using stacking structures or integration structures.

Another object of the present invention is to provide microwave devices miniaturized at a minimum.

A further object of the present invention is to provide microwave devices that show various pass band characteristics by employing diverse structures of microstrip metal lines.

Embodiments of the present invention to achieve the above objects, such as microwave filter, multiplexer, antenna and waveguide, are characterized in that they have a common configuration comprising: (a) a substrate made of a first dielectric substance; (b) a micro-strip metal line formed on one side of the first dielectric substrate; (c) a first ground metal film formed on the other side of the first dielectric substrate; (d) a structure having PBG that is formed along the micro-strip line; (e) a second dielectric coating layer that covers the surface of the substrate on which the micro-strip metal line is formed; and (f) a second ground metal film for field shield formed on the second dielectric coating layer, wherein the first dielectric substrate and the second dielectric coating layer are made of a flexible material.

The waveguide of the present invention can use the above common configuration as it is, and the antenna only needs to be equipped with input terminal in addition to the above common configuration.

Also, the microwave filter of the present invention is equipped with input terminal and output terminal in addition to the above common configuration. The microwave multiplexer has basically the same configuration as that of the above microwave filter of the present invention, but is different from the filter in that on one side of the first dielectric substrate are formed at least two micro-strip metal lines that have a part connecting to each other.

Such microwave filter, multiplexer, antenna and waveguide can be made employing stacking structures whereby components are stacked twice or more and the ground metal films are electrically connected with each other.

In addition, all the components can be made of flexible materials, and so can

be rolled in the form of a scroll as a whole.

In this way, a periodic change of impedance will occur, and so a PBG structure that does not allow microwaves of a specific frequency range to pass is resulted; field shield is conducted by the second ground metal film, and so there is no fear of malfunction due to mutual interference between signals of adjacent micro-strip metal lines even when the above microwave devices are manufactured in the form of a stacking or integration structure; and the miniaturization of the microwave devices can be realized.

If the PBG structure includes a first PBG structure of a period d1 and a second PBG structure of a period d2, and the first PBG structure and the second PBG structure are formed and arranged along the micro-strip metal line in such a way that the first PBG and the second PBG are separated from each other with a gap of d that is different from d1 or d2, microwave devices that show diverse pass band characteristics can be implemented.

The device of the present invention can be used as a frequency selective filter, a divider, or a multiplexer in the microwave range, as a noise elimination filter for devices used in the microwave range such as a PCS phone, a cellular phone, and so on, and as a signal dividing device for a microwave repeater, and so on.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A to FIG. 1C are plane views illustrating microwave filters according to embodiments of the present invention, after the second dielectric coating layer and the second ground metal film for field shield have been eliminated therefrom;

FIG. 1D is a sectional view along the line A-A' of the FIG. 1A, with the second dielectric coating layer and the second ground metal film being illustrated;

FIG. 2A and FIG. 2B are plane views illustrating microwave multiplexers according to embodiments of the present invention, after the second dielectric coating layer and the second ground metal film for field shield have been eliminated therefrom;

FIG. 3 is a schematic sectional view of a microwave filter made in the form of a scroll according to an embodiment of the present invention; and

FIG. 4 is a schematic sectional view of a microwave filter made in the form of a pressed scroll according to an embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference to attached figures, desirable examples of the embodiment of the present invention are to be explained in the following.

Although the filter and the multiplexer alone are selected as examples of the embodiment of the present invention, it is evident that the present invention can be applied to a microwave waveguide, an antenna, and so on without deviating from the idea of the present invention.

FIG. 1A and FIG. 1B are plane views illustrating microwave filters according to embodiments of the present invention, after eliminating the second dielectric coating layer and the second ground metal film for field shield.

Referring to FIG. 1A, a micro-strip metal line 12 is formed on the upper side of a substrate 10 made of a first dielectric substance, and a first ground metal film (not shown) on its lower side, respectively. The micro-strip metal line 12 has a PBG structure comprising a plurality of width parts 15 that have width greater than its own. On the other hand, a second dielectric coating layer and a second ground metal film that are not illustrated are successively formed on the surface of the substrate on which the micro-strip metal line 12 is formed.

Referring to FIG. 1B, it may be readily understood that the strip line is arranged in a form of "ㄹ" where it is bent and turned several times to minimize its lengthwise size.

FIG. 1C is a plane view of a wide bandwidth stop filter, an example of devices of the present invention. Referring to FIG. 1C, a micro-strip metal line 12 is formed on the upper side of a dielectric substrate 10, and a ground metal film (not shown) on its lower side, respectively. A plurality of width parts 15 that have width greater than that of the micro-strip metal line 12 are formed along the metal line 12. Here, the different width parts 15 refer to PBG structures where a polygonal figure such as a square, a circle, and so on is inserted into the micro-strip line, or the width of the line itself is changed. A first PBG structure 14A and a second PBG structure 14B are formed with the same periodic gap (d1= d2). And a gap (d) between the first PBG structure 14A and the second PBG structure 14B has a value different from the gap (d1) of the first PBG structure 14A and of the second PBG structure 14B. If d1 equals d, and so the lattices of the PBG structure are all formed with the same

periodic gap, the device will show stop band characteristics alone. When a structure where periodicity is destroyed in this way is adopted, a pass band occurs thereby. Accordingly, such a case shows pass band characteristics for narrow-width frequencies within a wide non-pass band.

On the other hand, if the first PBG structure 14A and the second PBG structure 14B are formed with different gaps (d1 is different from d2), then pass bandwidth will be widened.

Diversifying pass band characteristics through altering the period of defect lattices applies equally to various devices to be mentioned later.

FIG. 1D is a sectional view according to the line A-A' of the FIG. 1A, with a second dielectric coating layer 10' and a second ground metal film 16' being illustrated. Referring to FIG. 1D, it may be understood that a micro-strip metal line 12 is not seen because it is hidden by a broader part 15 formed on the upper side of the first dielectric substrate 10. The micro-strip metal line 12 on the first dielectric substrate 10 acts as a waveguide to guide microwaves. And the second ground metal film 16' performs the function of a field shield. Accordingly, in case of a stacked-type microwave frequency selective filter that is made through stacking many of the structures of FIG. 1C, the second ground metal film 16' can prevent interference between microwave signals transmitted through the micro-strip metal line 12. The first dielectric substance and the second dielectric substance may be the same or different. The second dielectric coating layer is formed to insulate the second ground metal film 16' from the microstrip metal line 12. And the first and second ground metal films 16 and 16' can be connected with each other by means of a metal part such as a connector, and so on or metal materials.

FIG. 2A and FIG. 2B are plane views illustrating microwave three terminal multiplexers according to embodiments of the present invention, after the second dielectric coating layer and the second ground metal film for field shield have been eliminated from them. Referring to FIG. 2A, micro-strip metal lines 12a and 12b are diverged in parallel arrangement on a substrate 10 made of a first dielectric substance. PBG structures 15a and 15b with width different from that of micro-strip metal lines 12a and 12b are formed on the metal lines 12a and 12b, respectively. Here, the diverged micro-strip lines may be arranged in parallel as shown in FIG. 2A or may be

formed in a shape of "ㄹ" as they are bent and turned several times as shown in FIG. 2B, so as to minimize their lengthwise size.

FIG. 3 is a schematic sectional view of a microwave filter made in the form of a scroll as an embodiment of the present invention.

Referring to FIG. 3, it may be seen that a first ground metal film 16, a substrate 10 made of a first dielectric substance, a micro-strip metal line 12, a second dielectric coating layer 10' and a second ground metal film 16', all of which are made of flexible materials, are successively stacked and rolled in the form of a scroll. Referring to the magnified part of FIG. 3, in the rolled area, the micro-strip metal line 12 and the ground metal films 16 and 16' do not immediately touch each other, and the first ground metal film 16 and the second metal film 16' adjoin immediately to each other, so that the field is completely shielded between the two ground metal films 16 and 16'. Here, as for the metal film and the micro-strip metal line, nothing hinders their stacking or rolling in the form of a scroll at all, since they are deposited to a thickness of several microns. Meanwhile the dielectric substrate and the dielectric coating layer are thicker than the metal film or the micro-strip metal line, and so they should have flexibility. Accordingly, high-polymer materials are used, e.g. aromatic polymers of high thermal stability such as polyimide, polyethylene terephthalate (PET), polyphenylene sulfone (PPS), and polyethyl naphthalene (PEN) system; inorganic polymers such as polydimethyl siloxanes; and thermosetting polymers such as the system of epoxy, phenoxy, and so on. All of these fall under typical polymer materials characterized by high thermal stability. It goes without saying that materials of flexibility can be developed without limit besides the above polymer materials, since polymer materials can be easily synthesized through modifying molecular structure. Therefore, it should be noted that the above listed are but representative examples.

If implemented as stated above, original features of a filter can be maintained as they are, even in case of stacking or rolling in the form of a scroll.

To make a microwave filter in the form of a scroll as in the above, the first dielectric substrate 10, the microstrip metal line 12, PBG structures including defect structure (not shown), and the first and second ground metal films 16 and 16' are all made of flexible materials.

A microwave multiplexer comprising at least two micro-strip metal line structures with parts that connect them with each other can also be made in the form of a scroll as in FIG. 3.

FIG. 4 is a schematic sectional view of a microwave filter made in the form of a pressed scroll according to an embodiment of the present invention. The filter of FIG. 4 is made in such a way that a filter of FIG. 3 is pressed so that its volume may be reduced.

On the other hand, apart from the above form of a scroll, a microwave device can also be made in the way of stacking where the first ground metal films 16 are connected with each other, or the first ground metal film 16 and the second ground metal film 16' are connected with each other.

INDUSTRIAL APPLICABILITY

According to the present invention, malfunction of the microwave devices employing micro-strip line structures, due to the interference between the signals of opposite micro-strip metal lines when miniaturizing the devices employing stacking structures, can be avoided regardless of the spacing of the lines. The second dielectric coating layer is formed to maintain a gap between the second ground metal film and a micro-strip metal line, which can contribute to keeping a steady gap and improving product durability. And diverged micro-strip lines are arranged in parallel with each other or in the shape of "ㄹ" where they are bent and turned several times, in order to minimize their lengthwise size. Also, they may be made in the form of a scroll to reduce their overall external size.

In addition, a microstrip line can include PBG structures having different periods, so that a microwave device showing pass band characteristics for narrow-width frequencies within a wide non-pass band may be implemented.

Herein above the invention has been described in reference to the preferred embodiments, but various other modifications and variations will be apparent to those skilled in the art without departing from the scope and spirit of the present invention.

What is claimed is:

1. A device acting as a microwave waveguide, the device comprising:

(a) a substrate made of a first dielectric substance;

(b) a micro-strip metal line formed on one side of the first dielectric substrate;

(c) a first ground metal film formed on the other side of the first dielectric substrate;

(d) a structure having PBG that is formed along the micro-strip line;

(e) a second dielectric coating layer that covers the surface of the substrate on which the micro-strip metal line is formed; and

(f) a second ground metal film for field shield formed on the second dielectric coating layer,

wherein the first dielectric substrate and the second dielectric coating layer are made of a flexible material.

2. The device according to the claim 1, wherein the PBG structure comprises:

a first PBG structure having a period of d1; and

a second PBG structure having a period of d2,

wherein the first and second PBG structures are arranged and formed along the micro-strip metal line in such a way that the first PBG structure and the second PBG structure are separated from each other with a gap of d that is different from d1 or d2.

3. The device according to the claim 1, wherein the device has a shape of a scroll pressed in one direction.

4. The device according to the claim 1, wherein the flexible material is selected from the group consisting of aromatic polymers of high thermal stability such as polyimide, polyethylene terephthalate, polyphenylene sulfone, and polyethyl naphthalene system; inorganic polymers such as polydimethyl siloxanes system; and thermosetting polymers such as the system of epoxy and phenoxy.

5. The device according to the claim 1, wherein the strip line is formed in such a way that it is bent and turned several times, in order to minimize its lengthwise size.

6. A device acting as a microwave antenna, wherein the microwave antenna device is made by equipping the waveguide device of claim 1 with an input terminal that inputs a signal of a predetermined frequency at one end of the waveguide device.

7. The device according the claim 6, wherein the PBG structure comprises:

a first PBG structure having a period of d1; and

a second PBG structure having a period of d2,

wherein the first and second PBG structures are arranged and formed along the micro-strip metal line in such a way that the first PBG structure and the second PBG structure are separated from each other with a gap of d that is different from d1 or d2.

8. The device according to the claim 6, wherein the device has a shape of a scroll pressed in one direction.

9. The device according to the claim 6, wherein the flexible material is selected from the group consisting of aromatic polymers of high thermal stability such as polyimide, polyethylene terephthalate, polyphenylene sulfone, and polyethyl naphthalene system; inorganic polymers such as polydimethyl siloxanes system; and thermosetting polymers such as the system of epoxy and phenoxy.

10. The device according to the claim 6, wherein the strip line is formed in such a way that it is bent and turned several times, in order to minimize its lengthwise size.

11. A device acting as a microwave filter, wherein the microwave filter device is made by equipping the waveguide device of claim 1 with an input terminal that inputs a signal of a predetermined frequency at one end of the waveguide device and by equipping the waveguide device of claim 1 with an output terminal that outputs a signal passed through the waveguide device at the other end of waveguide device.

12. The device according to the claim 11, wherein the PBG structure comprises:

a first PBG structure having a period of d1; and

a second PBG structure having a period of d2,

wherein the first and second PBG structures are arranged and formed along the micro-strip metal line in such a way that the first PBG structure and the second

PBG structure are separated from each other with a gap of d that is different from d1 or d2.

13. The device according to the claim 11, wherein the device has a shape of a scroll pressed in one direction.

14. The device according to the claim 11, wherein the flexible material is selected from the group consisting of aromatic polymers of high thermal stability such as polyimide, polyethylene terephthalate, polyphenylene sulfone, and polyethyl naphthalene system; inorganic polymers such as polydimethyl siloxanes system; and thermosetting polymers such as the system of epoxy and phenoxy.

15. The device according to the claim 11, wherein the strip line is formed in such a way that it is bent and turned several times, in order to minimize its lengthwise size.

16. A device acting as a microwave multiplexer, the device comprising:

(a) a substrate made of a first dielectric substance;

(b) at least two micro-strip metal lines formed on one side of the first dielectric substrate, and having a part that connects them with each other;

(c) a first ground metal film formed on the other side of the first dielectric substrate;

(d) structures, each having PBG that is formed along the micro-strip line;

(e) a second dielectric coating layer that covers the surface of the substrate on which the micro-strip metal lines are formed; and

(f) a second ground metal film for field shield formed on the second dielectric coating layer,

wherein the first dielectric substrate and the second dielectric coating layer are made of a flexible material.

17. The device according to the claim 16, wherein the PBG structure comprises:

a first PBG structure having a period of d1; and

a second PBG structure having a period of d2,

wherein the first and second PBG structures are arranged and formed along the micro-strip metal line in such a way that the first PBG structure and the second PBG structure are separated from each other with a gap of d that is different from d1

or d2.

18. The device according to the claim 16, wherein the device has a shape of a scroll pressed in one direction.

19. The device according to the claim 16, wherein the flexible material is selected from the group consisting of aromatic polymers of high thermal stability such as polyimide, polyethylene terephthalate, polyphenylene sulfone, and polyethyl naphthalene system; inorganic polymers such as polydimethyl siloxanes system; and thermosetting polymers such as the system of epoxy and phenoxy.

20. A device according to the claim 16, wherein each of the strip lines is formed in such a way that it is bent and turned several times, in order to minimize its lengthwise size.

FIG. 1A

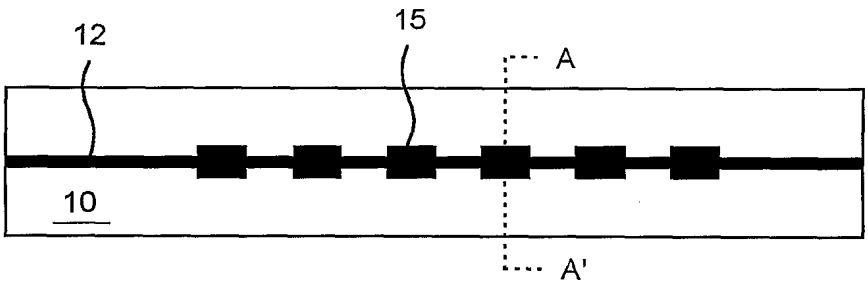


FIG. 1B

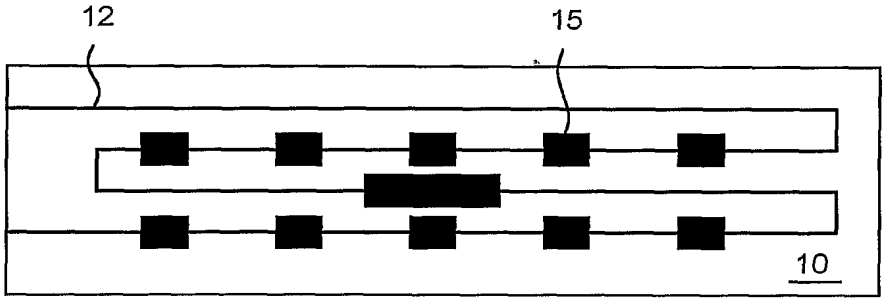


FIG. 1C

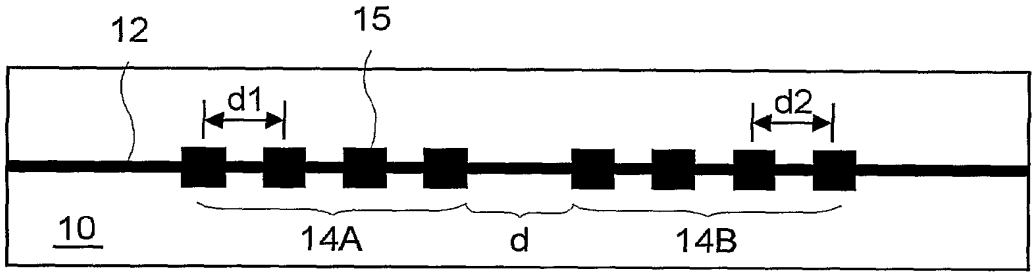


FIG. 1D

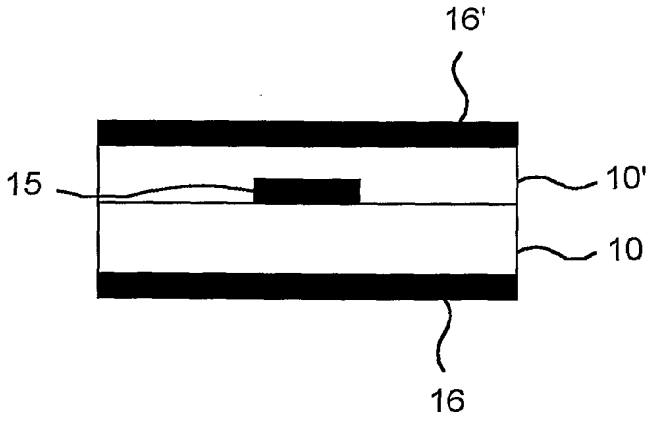


FIG. 2A

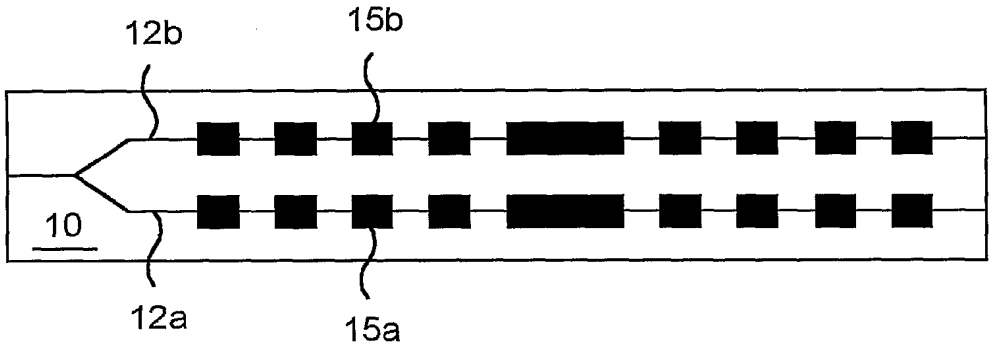


FIG. 2B

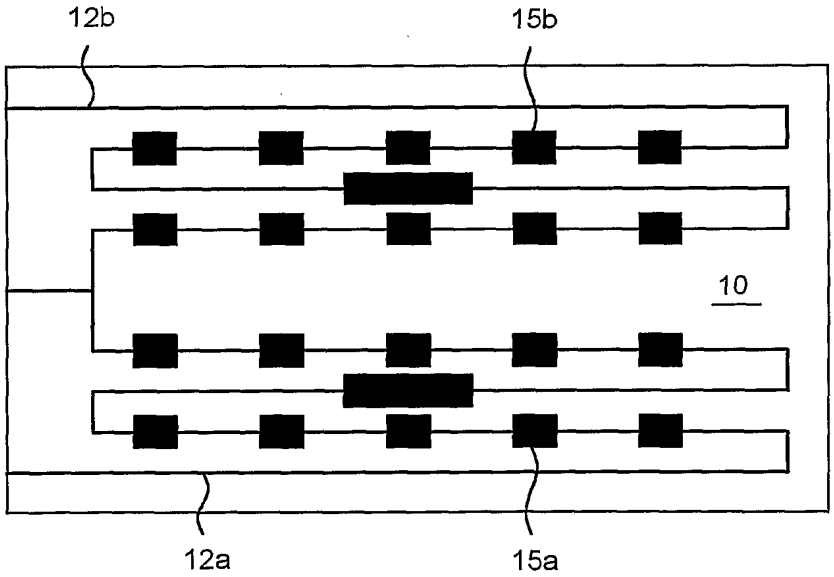


FIG. 3

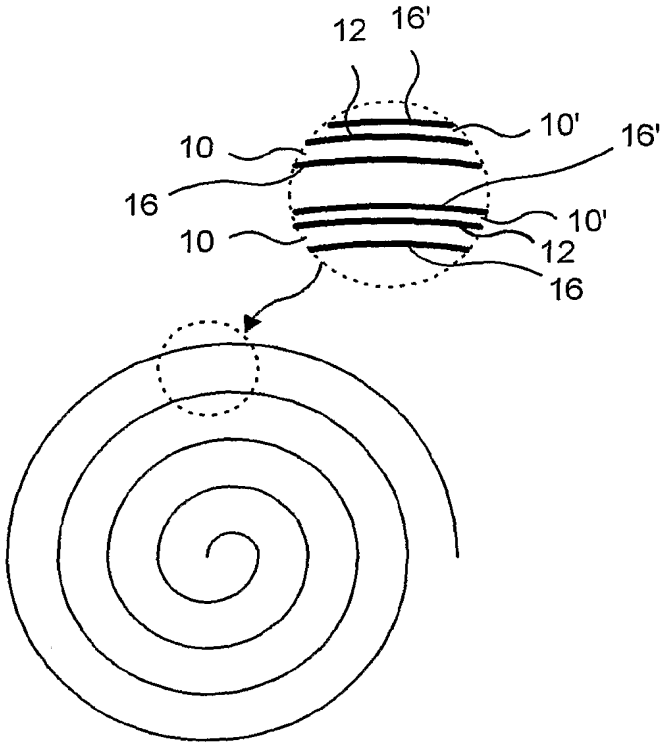
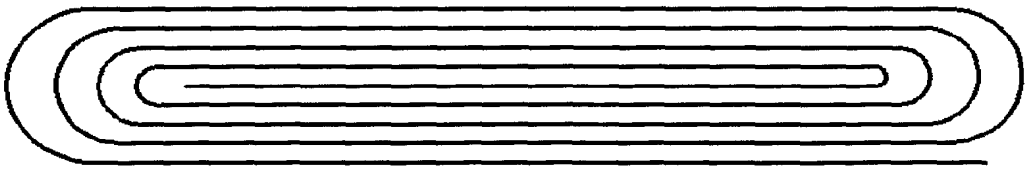


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR01/00712

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H01P 1/213

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimun documentation searched (classification system followed by classification symbols)

Documentation searched other than minimun documentation to the extent that such documents are included in the fileds searched

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search trerms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 345 205 A (General Electric Company) 6 SEP. 1994 see the whole document	1, 5, 6, 10,11, 15, 16, 20
A	US 4 675 627 A (Gogers Corporation) 23 JUN. 1987 see the whole document	1, 3, 6, 8, 10, 11, 13, 15, 16, 18, 20
A	US 4 916 417 A (Murata Mfg. Co., Ltd.) 10 APR. 1990see the see the abstract and Fig. 1-2 US 5 A (General Electric Company) 6 SEP. 1994	1, 16
A	US 4 583 064 A (Matsushita Electric Industrial Co.) 15 APR. 1986 see the whole document	1, 16

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
25 AUGUST 2001 (25.08.2001)	27 AUGUST 2001 (27.08.2001)

Name and mailing address of the ISA/KR	Authorized officer
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